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# Effect of electromagnetic field interaction on photon emission of infusions of selected plants

***Abstract**. Eucalyptus belongs to the Myrtaceae family, comprising some 900 species and subspecies. Eucalyptus leaf extracts have been approved for use as food additives, and are now also used in cosmetic preparations. Plants have a wide range of chemical and physical defense mechanisms against external threats. Most essential oils have some degree of antimicrobial activity, which can be attributed to the presence of a number of terpenoid and phenolic compounds. Essential oils have the potential to deal with various cellular and molecular cascades. Strong fields cause significant stretching of bonds in the molecule, and these fields can also cause geometric changes. EEF-induced global geometric changes are ubiquitous in organometallic and coordination complexes. The purpose of the study was to determine the possibility of identifying changes in the biological substance on the basis of photon emission characteristics. In addition, to determine the variation in photon emission of infusions of selected herbs that were subjected to the action of a constant electric field. The impact of the electric field affects the photon emission of biological material in a heterogeneous manner. The greatest decrease in the number of photons was observed with a three-hour stimulation with an electric field of 2.2 kV/cm. The use of different parameters of voltage and stimulation time modifies the structure of photon emission, thus providing an opportunity to identify the degree of interaction.*

***Streszczenie.** Eukaliptus należy do rodziny Myrtaceae, obejmującą około 900 gatunków i podgatunków. Ekstrakty z liści eukaliptusa zostały dopuszczone do stosowania jako dodatki do żywności, obecnie wykorzystuje się je także w preparatach kosmetycznych. Rośliny posiadają szeroki zakres chemicznych i fizycznych mechanizmów obronnych przed zagrożeniami zewnętrznymi. Większość olejków eterycznych ma pewien stopień działania przeciwdrobnoustrojowego, co można przypisać obecności szeregu związków terpenoidowych i fenolowych. Olejki eteryczne mają potencjał do radzenia sobie z różnymi kaskadami komórkowymi i molekularnymi. Silne pola powodują znaczne rozciąganie wiązań w cząsteczce, pola te mogą również powodować zmiany geometryczne. Globalne zmiany geometryczne wywołane EEF są wszechobecne w kompleksach metaloorganicznych i koordynacyjnych. Celem badań było określenie możliwości identyfikacji zmian w substancji biologicznej na podstawie charakterystyki emisji fotonowej. Ponadto określenie zróżnicowania w emisji fotonowej naparów wybranych ziół, które poddano oddziaływaniu stałego pola elektrycznego. Oddziaływanie pola elektrycznego wpływa na emisję fotonową materiału biologicznego w sposób niejednorodny. Największy spadek liczby fotonów odnotowano przy trzygodzinnej stymulacji polem elektrycznym o napięciu 2,2 kV/cm. Zastosowanie różnych parametrów napięcia oraz czasu stymulacji modyfikuje strukturę emisji fotonowej, dając tym samym możliwość identyfikacji stopnia odziaływania. (**Wpływ oddziaływania pola elektromagnetycznego na emisję fotonową naparów wybranych roślin**).*

**Keywords**: photon emission, essential oils, eucalyptus, electric field
**Słowa kluczowe**: emisja fotonowa, olejki eteryczne, eukaliptus, pole elektryczne

## Introduction

Eucalyptus is a member of the Myrtaceae family, comprising some 900 species and subspecies. Although eucalyptus is a widespread plant in many countries around the world, Australia is probably the only country where eucalyptus dominates most of the landscape. Eucalyptus leaf extracts have been approved for use as food additives, and are now also used in cosmetic preparations. Attention has been paid to the functional properties of these extracts. Studies have shown that the extracts exhibit diverse biological activities, including antimicrobial, antihyperglycemic and antioxidant effects, with the essential oils playing a key role in these biological functions [1]. Plants are known to have a wide range of chemical and physical defense mechanisms against external threats. These include milky sap, sticky resins, tough tissues, thorns, thorns, and short "hair-like" trichomes. Chemical defenses can repel insects and/or fight the nervous system, as well as the endocrine glands of pests and herbivores. Essential oils are active components of the chemical defense mechanisms of plants [2]. Most essential oils have some degree of antimicrobial activity, which can be attributed to the presence of a number of terpenoid and phenolic compounds that have been shown to exhibit antimicrobial activity in their pure form. These properties are partly related to their lipophilic nature, leading to accumulation in membranes and subsequent membrane-related events such as energy depletion. Phenolic components of essential oils sensitize the phospholipid bilayer of the cell membrane, causing increased permeability and leakage of important intracellular components or impairment of microbial enzyme systems. The chemical composition and biological activities of essential oils are reviewed, including antimicrobial properties and potential applications in food products [1]. Essential oils have the potential to deal with various cellular and molecular cascades. In a review of chemotherapeutic agents, it was revealed that more than 50% of conventional chemotherapeutic drugs are of plant origin, while half of them are modified chemical compounds of phytoproducts and others are direct plant derivatives [2].

It has long been known that electric field effects are ubiquitous in chemical biology. The biocatalytic function of many substances is significantly influenced by electrostatic fields mediated by charged functional groups dispersed. The study of EEFs is not only relevant to organic chemistry, but also has a direct impact on the understanding of chemical compound function and biocatalysis. Electric fields in biomolecules are usually referred to as LEFs. In biological systems, external electric fields are generally local, caused by the presence of charged functional groups. In enzymes, electric fields are generated by point charges in the side chains of amino acids dispersed throughout the protein. Although electrostatic interactions in proteins are the most obvious manifestations of electric fields in biological systems, other bio-molecules also contain electric fields. An example is DNA molecules, in which LEFs arise from negative charges on backbone phosphates. These negative charges have so far been linked mainly to the stability they provide to the DNA molecule in its folded form. The intensity of the LEF field in biomolecules largely depends on the type of molecule under consideration. The LEF in DNA is about 0.3 V/å, while the LEF in a simple protein helix is only 0.1 V/å [3,4].

Strong fields cause significant stretching of bonds in the molecule, and these fields can also cause geometric changes in the molecule as a whole. EEF-induced global geometric changes are ubiquitous in organometallic and coordination complexes. The greatest effect of EEFs on geometry can be expected for aggregates held together by weak interactions - hydrogen bonds or van der Waals bonds. Among other things, it has been shown that electric fields of relatively low intensity are able to affect the organization of molecular networks, protein folding, 77 the formation of ordered clusters of water and ionic liquids. A practical manifestation of this increased susceptibility of aggregates to electric fields is the use in the food industry of so-called pulsed electric fields of relatively low intensity (usually only 20-80 kV/m) for the disintegration of bacterial biological tissues with the aim of improving the preservation time of food products [5-8]. Cascade lasers have recently become important in this area and can be used for the above purposes due to their great ability to tune the emitted fields [9-10]

The purpose of the study was to determine the possibility of identifying changes in biological substance based on photon emission characteristics. In addition, to determine the variation in photon emission of infusions of selected herbs that were subjected to a constant electric field.

## Material and methods

Eucalyptus oil was used for the study, from which 4 samples each were prepared in ten replicates: a control sample and three samples subjected to a constant electric field (Figure 1), with electric voltages of 2.1 kV/cm, 4.2 kV/cm and 8.6 kV/cm and in three variants of stimulation time of 1, 2 and 3 hours. Immediately after stimulation, ultra-weak luminescence was measured. The photon emission measurement was performed at the Laboratory of Experimental Research Techniques of Raw Materials and Biological Products of the Agricultural University of Cracow, which has an in-house procedure accredited by the Polish Center for Accreditation for the measurement of the number of photons.

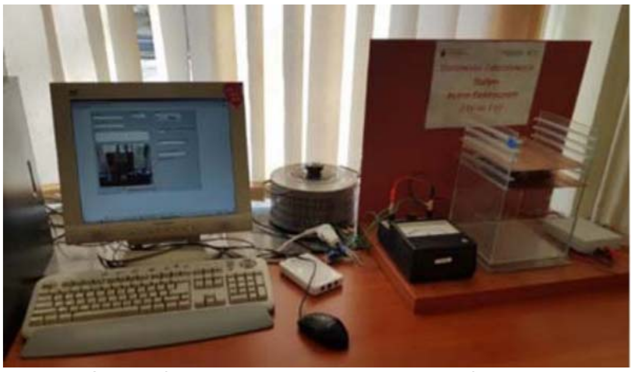
Figure 1. Stand of exposure to a constant electric field [11,12].

The Single Photon Counting method was used to determine the emission of ultra-weak photons (Figure 2). The result of the photon emission measurement is the absolute difference between the number of photons recorded by the photomultiplier in the light-proof chamber with the material and the number of photons recorded by the photomultiplier in this chamber without the material, according to the relation 1 [13]:

(1) $$L = A - B \text{ [impulse]}$$

where: L - the number of photons emitted by the test sample, A - the number of photons emitted by the sample placed in the light-tight chamber, B - number of indications (photons) generated by the empty light-tight chamber


Figure 2. Photon emission measurement device [14-16].

## Results

The present study investigated the luminescence properties of eucalyptus oil, which was exposed to a constant electric field at different exposure times. Figures 3 - 5 show the total average number of photons emitted from the essential oil samples.

When eucalyptus oil was subjected to a constant electric field of 2.2kV/cm (Figure 3), it was found that the number of photons decreased regardless of exposure time compared to the control sample. An alternating upward trend and a downward trend in the average number of photons was observed for the samples exposed to the electric field. For the sample subjected to an hour-long exposure to an electric field, a decrease in the number of photons by 85 was recorded compared to the control sample. On the other hand, for samples whose exposure was two and three hours, the number of photons recorded was lower by 64 and 86 photons, respectively. The number of photons obtained for the eucalyptus oil samples subjected to one-hour and three-hour exposure were similar to each other, while the number of photons obtained for the sample subjected to two-hour exposure was half as high. It should be noted that the photon emission values obtained from samples subjected to different exposure times were significantly different, indicating the differential effects of 2.2 kV/cm electrical exposure on eucalyptus oil.

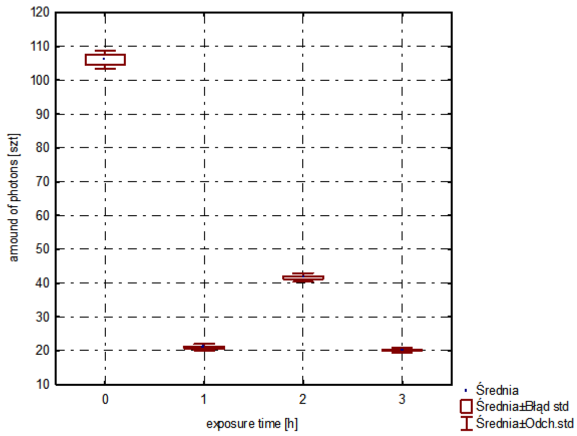

Figure 3. Photon emission of eucalyptus oil recorded after exposure to an electric field of 2.2 kV/cm

Figure 4 shows the effect of exposure to an electric field of 4.2 kV/cm on eucalyptus oil. It was noted that the number of photons decreased compared to the control sample. A decreasing trend in the average number of photons was observed for the samples exposed to the electric field. The number of recorded photons for those samples subjected to 1, 2 and 3-hour exposure was photons, respectively. The highest number of photons was obtained for the sample subjected to one-hour exposure, and the lowest for the sample subjected to three-hour exposure. It should be noted that the photon emission values obtained from samples subjected to different exposure times were significantly different, indicating the differential effects of electrical exposure at 4.2 kV/cm on eucalyptus oil.

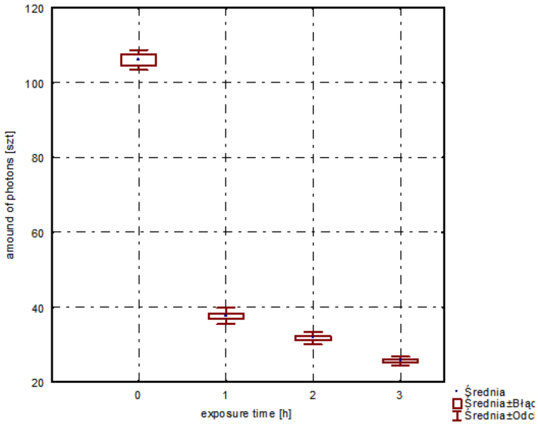


Figure 4. Photon emission of eucalyptus oil recorded after exposure to an electric field of 4.2 kV/cm

When eucalyptus oil was exposed to an electric field of 8.6 kV/cm (Figure 5), it was found that the number of photons decreased significantly compared to the control sample not depending on the exposure time. An upward trend in the average number of photons was observed for samples exposed to the electric field. For the sample subjected to one hour of electric field exposure, a decrease in the number of photons by 84 compared to the control sample was observed, for the sample subjected to two hours of electric field exposure the number of photons decreased by 79 compared to the control sample, while for the sample subjected to three hours of electric field exposure the number of emitted photons decreased by 67 compared to the control sample. The highest number of photons was obtained for the sample subjected to three-hour exposure, and the lowest for the sample subjected to one-hour exposure. It should be noted that the photon emission values obtained from the samples subjected to different exposure times were significantly different, indicating the differential effect of the 8.6 kV/cm electric exposure on eucalyptus oil.

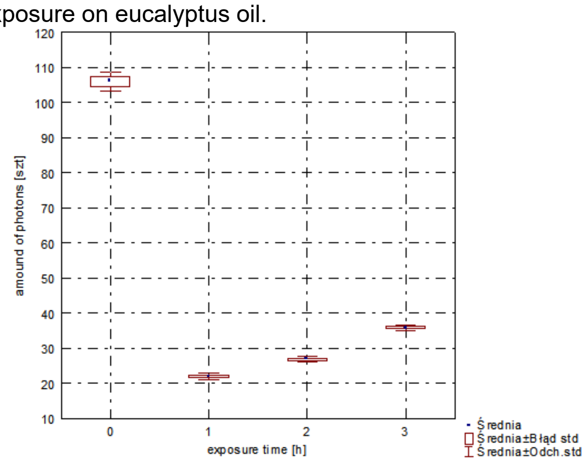


Figure 5. Photon emission of eucalyptus oil recorded after exposure to an electric field of 8.6 kV/cm

Figure 6 shows the relationship between exposure to a constant electric field and exposure time and the number of photons emitted by eucalyptus oil. In order to obtain the highest number of photons of eucalyptus oil, it is necessary to choose the parameters of electric field voltage and exposure time so that the combination of these parameters situates the system in the red region and does not exceed the yellow limit line. The lowest values of the number of photons of essential oil (less than 22 photons) were obtained for an electric voltage value of 2 kV/cm and an exposure time of one hour (dark green color area).

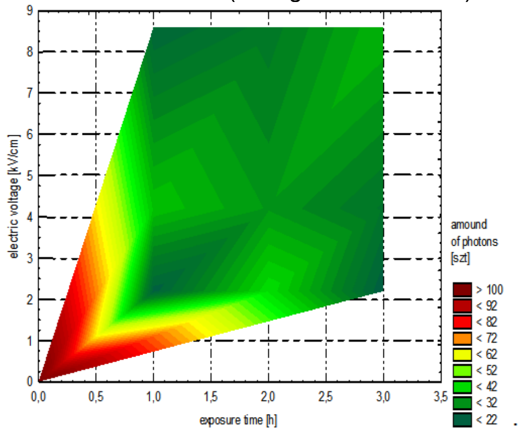


Figure 6. Effect of constant electric field interaction on photon emission of eucalyptus oil.

A one-way analysis of variance (ANOVA) was performed, for which Statistica 13 (StatSoft, Inc., Tulsa, OK, USA) was used. The significance of differences between the means was verified using Scheffe's test (α=0.05). The results are shown in Tables 1 and 2. Two homogeneous groups of photon count values were distinguished depending on the applied electrical voltage. The first homogeneous group included the photon number value obtained for the control sample. The second included the values obtained for the test samples subjected to an electric field with voltage values of 2.2 kV/cm, 4.2 kV/cm and 8.6 kV/cm. This shows that the values of the number of photons varied between homogeneous groups.

Table 1. The number of photons of eucalyptus oil depending on the applied electric voltage.

| Electric voltage [kV/cm] | Amount of photons [psc] |
|---|---|
| 0 | 106[a] |
| 2,2 | 27,58[b] |
| 4,2 | 31,6[b] |
| 8,6 | 28,3[b] |

*- calculations performed at the significance level of α=0.05*
*a - first homogeneous group, b - second homogeneous group*

Three homogeneous groups of photon number values were distinguished depending on the electric field exposure time used. The first homogeneous group included the photon number value obtained for the control sample. The second included the values obtained for samples subjected to one-hour and three-hour electric field exposure. While the third group included the value of the number of photons obtained for the sample subjected to a two-hour exposure This shows that the value of the number of photons varies between homogeneous groups [17-22].

Table 2. the number of photons of eucalyptus oil depending on the applied time of electric field exposure

| Exposure time [h] | Amount of photons [psc] |
|---|---|
| 0 | 106[a] |
| 1 | 26,88[b] |
| 2 | 33,42b[c] |
| 3 | 27,2[b] |

*- calculations performed at the significance level of α=0.05*
*a - first homogeneous group, b - second homogeneous group*

**Conclusion**

The impact of an electric field affects the photon emission of biological material in a heterogeneous manner. The greatest decrease in the number of photons was observed with a three-hour stimulation with an electric field of 2.2 kV/cm. The use of different parameters of voltage and stimulation time modifies the structure of photon emission, thus providing an opportunity to identify the degree of interaction. Mączka, M. Effective Simulations of Electronic Transport in 2D Structures Based on Semiconductor Superlattice Infinite Model. Electronics 2020, 9, 1845. https://doi.org/10.3390/electronics9111845

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